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Research Article

A review on financial failure models- The case of manufacturing industry

Finansal başarısızlık modelleri üzerine bir inceleme- İmalat sanayi örneği

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Abstract

Increasingly globalized economic and financial dynamics create extensive complexity and uncertainty for national economies and businesses. As a result of this financial stress experienced by firms, researchers have developed models using financial ratios to measure the financial health of firms. One of the implications of this situation for academic research is the continued importance of predicting and modelling financial failure for businesses. This study aims to apply existing financial failure and bankruptcy prediction models to the financial data of 45 manufacturing enterprises traded in Borsa Istanbul and to establish a comparative analysis framework of the prediction results. In order to explain the risk of financial failure and bankruptcy, the financial statements of the enterprises covering the years 2011-2020 are used as a data set. Altman Z-Score, Springate S-Score and Zmijevski J-Score values of these 45 enterprises were calculated and based on them, predictions were made about the financial viability of the enterprises. In addition, financial failure models measured by Altman Z-Score, Springate S-Score and Zmijevski J-Score were used in the study. According to the findings, while Altman Z-Score and Springate S-Score show similar results, they are not similar to the results of Zmijevski J-Score.

Keywords: Financial Failure, Bankruptcy, Altman Z-Score, Springate S-Score, Zmijevski J-Score

Jel Codes: C35, G17, Z23

Öz

Küresel iktisadi ve finansal dinamikler ulusal ekonomiler ve işletmeler üzerinde giderek artan boyutlarda karmaşıklık ve belirsizlik üretmektedir. Firmaların yaşadıkları bu finansal stresin sonucu olarak yatırımcılar başarısızlık korkusu içerisinden riskten kaçma eğilimi içerisine girerler. Bu sonuç doğrultusunda araştırmacılar bir firmanın finansal olarak başarı ve başarısızlığı ölçmek amacıyla finansal oranlardan yararlanarak modeller geliştirmişlerdir. Bu durumun akademik araştırmalara yansımalarından biri işletmeler için finansal başarısızlığın tahmin ve modellenmesinin önemini muhafaza ediyor olması olgusudur. Bu çalışmanın amacı mevcut finansal başarısızlık ve iflas tahmin modellerini Borsa İstanbul'da işlem görmekte olan 45 İmalat sanayi işletmesinin finansal verilerine uygulayarak tahmin sonuçlarının mukayeseli bir analiz çerçevesini oluşturmaktır. Finansal başarısızlık ve iflas riskini açıklamak için işletmelerin 2011-2020 yıllarını kapsayan finansal tabloları veri seti olarak kullanılmıştır. Söz konusu 45 işletmenin Altman Z- Skor, Springate S- Skor ve Zmijevski J- Skor değerleri hesaplanmış ve bunlara dayanarak işletmelerin finansal başarısızlıkları hakkında tahminde bulunulmuştur. Araştırmada kullanılan finansal başarısızlık model sonuçları Altman Z-Skor, Springate S-Skor ve Zmijevski J-Skorları ile ölçülen finansal başarısızlık riskidir. Elde edilen bulgulara göre Altman Z-Skorunun Springate S-Skoru ile paralel seviyede sonuçlar gösterirken Zmijevski J-Skor'un verdiği sonuçlar ile benzerlik göstermemektedir.

Anahtar Kelimeler: Finansal Başarısızlık, İflas, Altman Z-Skor, Springate S-Skor, Zmijevski J-Skor

JEL Kodları: C35, G17, Z23

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Introduction

Companies may experience financial difficulties from time to time. They may be unable to sustain their lives due to problems arising from business management and financial reasons, economic crises in the country where businesses operate, political issues, or global economic crises.

Deteriorations in the financial structure of a business may eventually cause concerns about the business's ability to survive. Failure to ensure business continuity due to financial difficulties and the emergence of various risks is referred to as financial failure in the literature.

The idea of financial failure continues to maintain its academic and practice-oriented importance as the pressure and risks on companies grow and become more complex due to developing technologies and increasing globalization. The magnitude and complexity of the risks and uncertainties may deteriorate the financial structure of the enterprises and eventually cause them to face the risk of bankruptcy. Therefore, financial distress models are essential conceptual elements in financial management, especially when businesses face financial difficulties for various reasons and business management does not develop the necessary early warning and follow-up systems. These developments eventually force the concept of financial failure, its theoretical framework, and applications to measure the dimensions of financial failure to become an integrated part of business management practices.

For businesses, the risk of financial failure arises due to a process that includes making wrong financial decisions. Based on this fact, it requires timely detection of financial problems and proper implementation of these models to solve the issues with an early warning system. In general, factors such as the ability to create high profitability ratios, avoiding high-cost borrowing structures, and ensuring sufficient liquidity levels are considered critical elements for the health of the financial structure of the enterprises. However, financial models in the business finance literature include early and timely detection indicators for analysing financial statements regarding potential financial distress and bottleneck areas.

These financial models function as an early warning system for possible threats to business life, such as financial failure and bankruptcy. Using these developed financial failure models aims to make potential financial stress areas predictable by systematically analysing the financial statements of the enterprises and interpreting the analysis results in a way that will serve as an early warning indicator for the future.

Beaver was the first researcher to use financial ratios to measure financial failure in his 1966 study. Since this date, researchers have focused on modelling and estimating financial stress and financial failure. As a result of the literature review carried out in the context of these developed models, it is seen that the z-score model developed by Altman in 1968 came to the fore.

Within the scope of this study, the historical financial data of 45 companies that are traded in Borsa Istanbul and operating in the manufacturing industry are examined. In addition, this study examines the predictions produced by the financial failure models regarding probable financial failure and financial stress problems in the future. In the first part of the study, the theoretical framework of the concept of financial failure and the analytical structures of the prediction models developed for measuring financial failure are examined. The second part of the study consists of a literature review on financial failure models. In the third and last part, the Altman Z-Score, Springate S-Score, and Zmijevski J-Score models are calculated using the companies' financial statements for 2011-2020. In line with the analytical structures of the models, the model results were evaluated comparatively. In the conclusion and evaluation part, a brief comparison of the financial failure and stress models included in the research is made, and suggestions about possible application and development areas are tried to be given.

Financial failure and forecast models

The increase in the pace of development of the business world brings intense competition. Free market dynamics, financial and economic crises, environmental and sustainability impacts and concerns, and international competition create pressures and constraints on businesses in various fields. Evaluation of the possible effects of these pressures and constraints on the enterprise’s success and viability makes it an essential element of its management function. Financial success and survival opportunities of businesses that cannot comply with and respond to the increasing competition conditions may be partially or eliminated. Therefore, objective identification, measurement, follow-up, and evaluation of financial stress and failure are among the priorities of enterprises.

Financial failure describes businesses experiencing financial problems and being forced to terminate their business activities (İloğlu, 2020). Financial failure refers to the difficulties businesses face in fulfilling their financial obligations or, worse, the inability to fulfil them (Terzi, 2011). Financial failure can end the lives of businesses and cause businesses to go to a new set of arrangements. Analysing the current strengths and weaknesses of the business, as well as possible opportunities and threats, improves the planning capabilities of the finance manager (Uzun, 2005).

Since monitoring financial failure prospects is vital in terms of its socio-economic consequences, focusing on it helps to find solutions to the problems that will occur. There are many environmental reasons why businesses experience financial failure. Moreover, the reasons that push businesses to financial failure can occur at almost every stage of business activities. Therefore, it is possible to divide the causes of business failure into internal and external factors (Uzun, 2005).

According to Akgüç (1989), the reasons for the failure of businesses can be listed as follows;

- Insufficient sales volume of enterprises
- Excessively high operating expenses
- Failure of businesses to collect receivables on time, increase in doubtful and worthless receivables
- Inventory turnover slower than desired
- To create idle production capacity in enterprises by investing primarily in tangible fixed assets
- Increased and excessive borrowing
- Making a mistake when choosing the place of establishment of the business
- Weakening of competition with other businesses in the market
- Mistake in company acquisitions
- Insufficient liquidity, failure to fulfil obligations on time
- Natural disaster situations
- Prolonged strikes that may occur in enterprises

Many methods are developed to anticipate these financial failures and take precautions. The most basic tool used in these methods is financial ratios. Financial ratios are calculated using financial statements for the current and prior periods to measure and analyse the financial position of a company (Uzun, 2005). These ratios are analysed in terms of the enterprise's operating performance development over time and compared with competitor enterprises operating in the same sector. In this way, the company management is provided with financial information that can be interpreted for future periods and an analysis basis for the dynamics of the operating performance in future periods.

A comprehensive review of the literature on financial failure studies in Turkey shows that companies are usually analysed and interpreted with only one financial failure model. Even though this type of study, which is common in the literature, provides meaningful results in predicting the financial health of companies, it is more difficult to interpret based on a single estimation method. In this context, it has been observed that the number of studies in which several different financial failure models are calculated, and their results are compared is insufficient. Based on this gap in the literature, in this study, by analysing their financial data between 2020-2011, three of the most widely accepted and used financial failure models were selected and applied to 45 manufacturing sector enterprises traded on the BIST 100. Z-score, s-score and j-score values were compared and interpreted, and the models' differences were determined. As a result of the study, it was determined that the Altman Z-score and Springate S-score models show similar results, while the Zmijevski j-score model gives different results from the previous two models.

Beaver model

The Beaver model for analysing financial failure emerged from a 10-year study between 1954 and 1964. The study analysed 79 enterprises classified as failures in financial criteria and 79 with successful financial status. The selected enterprises are of similar size and operate in the same sector. In this model, a total of 30 ratios are used. In addition, the t-analysis framework is extended to cover past periods up to five years before the firm's bankruptcy (Beaver, 1969). The ratio groups Beaver chose to use in his study are as follows:

- Cash Flow/Total Debt

- Net Profit/Total Assets
- Total Debt/Total Assets
- Current Assets/Short-Term Liabilities
- Net Working Capital/Operating Expenses
- Net Working Capital/Total Assets.

The study was conducted using three separate tests and stages in the analysis. These stages:

- Comparison of Ratio Averages
- Dichotomous Classification Test
- Investigation of Probability Distributions

In the first of these tests, the averages of the ratios of the enterprises whose financial conditions were classified as successful and unsuccessful were taken, and a comparison was made over the average values. It was found that the values differed significantly from each other as we moved from the years before the financial failure to the first year analysed.

A binary classification test was used in the second stage of the test. With this test, each ratio used in the model was applied to all the selected enterprises to measure whether financial success or failure would be experienced.

Two types of errors can occur in this binary classification test. The first type of error is the failure of the model result of a financially successful enterprise. The second type of error means that the result of the model applied to a financially unsuccessful business is successful. The margin of error for the first type is 22 per cent, and the margin of error for the second type is 5 per cent (Outecheva, 2007).

In the last stage of Beaver's test, the ratio distributions of the ratios analysed were calculated. In this study, Beaver proved that the cash flow/total debt ratio is one of the most effective ratios that can be used to detect a business failure and gives effective results.

Weibel model

In the research conducted by Weibel, 36 firms with successful financial status and 36 firms with financial failure were selected using criteria such as the sectors in which the enterprises operate, years of operation, size, legal structure, and place of establishment. These selected firms were subjected to the Wilcoxon analysis test. Within the scope of the analysis, 20 ratios were used, which were grouped into six components. These are (Yıldırım, 2006):

- Cash Flow/Short-Term Liabilities
- Current Assets/Short-Term Liabilities
- Working Capital / (Operating Expenses - Depreciation)
- Inventory Turnover
- Liabilities/ Shareholders' Equity

The Wilcoxon test is a univariate statistical analysis method. This test ignores the sample's independence and does not consider the multiple relationships of the existing variables. Therefore, the selected set of ratios can be interpreted differently and give different results since they are chosen with a subjective decision. Moreover, according to the test, the interpretation of the results does not depend on a certain systematization (Titiz, 2000).

Sinkey model

Sinkey is one of the most important studies to classify bank failures, and his model aims to determine whether there is a significant difference between successful and unsuccessful banks. In his study, Sinkey examines 62 banks on the FDIC's (Federal Deposit Insurance Corporation) list of troubled banks and tries to model financial failure. Sinkey pays attention to the fact that the selected banks have similar structural characteristics and analyses the financial data of the two groups, which he divides into troubled and problematic banks, to reveal the differences in their operations and financial behaviour. In this study, Sinkey uses a univariate analysis of variance and classifies the ratios he chooses to use in this analysis under four main groups (Yıldırım, 2006).

Capital Adequacy;

- Shareholders' Equity / Total Assets
- Equity / Assets at Risk
- Total Equity Accounts / Risky Assets
- Loans / Equity

Liquidity Ratios;

- Treasury Bonds / Total Assets
- Cash / Total Assets
- Other Government Bonds / Total Assets

Efficiency Ratios;

- Net Profit / Total Assets
- Net Profit / Shareholders' Equity

Profitability Ratios;

- (Interest + Commission) / Total Operating Profit

Altman z-score model

Many models have been developed to predict financial failure. Among these models, the most widely used and well-known model is the Altman Z-Score model. In his study, Altman compared 33 bankrupt and 33 non-bankrupt firms operating in the manufacturing sector between 1946 and 1965. After making this application with 22 variables, Altman determined the five ratios that gave the best results among these variables and formed the discriminant model (Altman, 1968).

The model is one of the best examples of discriminant analysis. With discriminant analysis, through an index derived from the values of more than one independent variable, it is possible to determine which of the predefined groups or groups the unit whose observation results are obtained belongs to and, therefore, which group it should be classified. The so-called Z-Score model was developed by Altman in 1968 (Okka, 2018). The Altman Z-Score model is as follows:

$$Z=0.012X_1 + 0.014X_2+ 0.033X_3 + 0.006X_4+ 0.999X_5$$

The five financial ratios selected are as follows:

X_1: Net Working Capital / Total Assets

X_2: Retained Earnings / Total Assets

X_3: Earnings Before Interest and Taxes / Total Assets

X_4: Total Market Value of Equity Shares / Book Value of Total Debt

X_5: Sales / Total Assets

Z-Score values are classified as follows;

- Values less than 1.81; Bankruptcy (financial failure); Danger area, the probability of financial failure is high.
- Values between 1.81 - 2.99; Healthy area; Grey area, financial failure is difficult to predict easily.

- Values greater than 2.99; Stable area; Financial failure seems unlikely to occur.

Since the Altman Z-Score model only applies to firms in the manufacturing sector listed on the stock exchange, Altman et al. developed the Zeta Model in 1977 for firms in the manufacturing industry that are not listed on the stock exchange (Şaşmaz, 2019).

Meyer and Pifer model

In 1970, Meyer and Pifer conducted a study on financial failure prediction. Unlike previous studies, they used multivariate regression analysis. In their research, they selected 39 of the 55 banks that failed in the period covering 1948-1965 in the USA and included them in the analysis. They randomly selected the same number of 39 banks among the successful banks, included them in the scope of the research, and formed the study sample consisting of 78 banks. With the regression analysis method, they used a dummy variable, taking the values of 0 and 1 as the dependent variable and 32 financial ratios determined as independent variables (Zinet, 2014).

As a result of the multiple regression they applied, financial failure forecasts are 80% successful 1 and 2 years before the relevant year. As a result, the model's coefficient of determination (R^2) was 70%, a high value. However, it was determined that the prediction percentages started to decrease, and the model became inadequate when periods longer than two years were used for forecasts (Zinet, 2014).

Springate s-score model

The Springate Model is developed by Gordon L.V. Springate using Multiple Discriminant Analysis (MDA). In this model, which is presented as a revolution of the Altman model, the 19 financial ratios most commonly used in the literature were initially preferred. However, after the tests, Springate chose four financial ratios to be used to determine the result better. As a result of this test applied to 20 successful and 20 unsuccessful businesses, the accuracy rate in measuring financial success was 92,5% (Husein & Pambekti, 2014).

Springate S- Score Model:

$S = 1.03X_1 + 3.07X_2 + 0.66X_3 + 0.4X_4$

X_1 = Working Capital / Total Assets

X_2 = Earnings Before Interest and Taxes/Total Assets

X_3 = Earnings Before Interest and Taxes / Short-Term Liabilities

X_4 = Sales / Total Assets

S-Score values are classified as follows;

- S-Score > 0.862; The business is considered safe (successful).
- S-Score < 0.862; The business is considered unsafe (unsuccessful).

Ohlson o-score model

James A. Ohlson developed the Ohlson Model in 1980. The Ohlson Model was introduced to reduce the method's limitations based on the sample size and numerous restrictive assumptions since the ratios in Altman's Z score model differ by industry. Ohlson uses the logit regression model in his study (Kulalı, 2014).

Ohlson's model tries to predict the probability of default (inability to fulfil obligations) of enterprises. Ohlson also uses an improved database derived from annual financial reports. The sample in this model includes 2058 firms that did not experience financial failure between 1970 and 1976 and 105 firms that went bankrupt. The model identifies four main factors that are statistically significant in assessing the probability of default (inability to fulfil obligations) within a year: business size, measurement of financial structure, measurement of performance, and measurement of liquidity (Outecheva, 2007).

O-Score Model:

$O = 0{,}407X_1 + 6{,}03X_2 + 1{,}43X_3 + 0{,}076X_4 - 1{,}72X_5 - 2{,}37X_6 - 1{,}83X_7 + 0{,}285X_8 - 0{,}521X_9 - 1{,}32$

(X_1) = Log (Total Assets /GDP Index)

(X_2) = Total Debt / Total Assets

(X_3) = Working Capital / Total Assets

(X_4) = Current Liabilities / Current Assets

(X_5) = 1;0 if Total Debt > Total Assets

(X_6) =Net Profit (NP)/ Total Assets

(X_7) = Earnings Before Interest Tax / Total Debt

(X_8) = 1 if net profit for the last two years is negative;0

(X_9) = $(N.K_t - N.K_{t-1})/(|N.K_t| + |N.K_{t-1}|)$

The O score obtained here is subjected to logistic transformation. For example, the following formula gives the logistic transformation (Şaşmaz, 2019).

$$\frac{e^{o\ skoru}}{1 + e^{o\ skoru}}$$

O-Score values are classified as follows;

- O-Score > 0.5; The business is in a safe condition (successful)
- O- Score < 0.5; Business is insecure (failing)

Zmijewski j-score model

The Zmijewski model was introduced in 1984 and categorized businesses that legally filed for bankruptcy as failing. Zmijewski tested his probit analysis model on 800 non-bankrupt and 40 bankrupt enterprises. The reliability of this model was found to be 99% (Bayramova, 2020).

Zmijewski model:

$J=-4.3-4.5X_1+5.7X_2+0.004X_3$

It's here,

(X_1) = Net Profits / Total Assets

(X_2) = Total Debt / Total Assets

(X_3) = Current Assets / Short-Term Liabilities.

J-Score values are classified as follows;

- J-Score < 0; The business is safe (successful)
- J- Score > 0; The business is insecure (failing)

Canada c-score model

The Canada C-Score model was applied to 173 businesses operating in Canada that have experienced financial failure. Multiple discriminant methods were used in the model. Therefore, it is considered more appropriate to apply the model to small enterprises (Şaşmaz, 2019).

The Canada C-Score function is as follows:

$C=4,59X_1+4,51X_2+0,3936X_3-2,76$

(X_1) =Shareholders' Shares / $Total\ Assets_{t-1}$

(X_2) = (Earnings Before Interest and Taxes + Finance Expenses$_{t-1}$)/Total Assets$_{t-1}$

(X_3) = Sales Revenue$_{t-2}$/ Total Assets$_{t-2}$.

Within the scope of the model, (t-1) = data from one year ago, while (t-2) = data from two years ago.

C-Score values are categorized as follows;

- C-Score>-0.3; Enterprise is in a safe state (successful)
- C- Score <-0.3; The business is insecure (failed)

Literature review

Chairunnisa, Arshed, and Shafitranata (2020) aimed to calculate the potential bankruptcy forecasts of Islamic banking using Altman Z-Score and Springate models. The financial data of 12 Islamic banks in Indonesia between 2013 and 2019 were analysed. As a result of the study, the Z-score estimated that 1.19% of Islamic banks are in the grey area and 98.81% are in a non-failure zone. At the same time, the S-Score showed that 38.10% of Islamic banks are in a financial distress position, and 61.90% are in a non-failure zone.

Öztürk and Yılmaz (2019) aim to analyse the relationship between Altman Z-Score and Beneish M-Score in the context of 17 companies traded in the BIST Emerging Companies Market. It is concluded that there is a significant relationship between financial distress and accounting manipulation. The Z-score values calculated with the data obtained from the financial statements of the enterprises with a high probability of manipulation are above the threshold value of 2.99 in parallel with this situation.

The research conducted by Soba, Akyüz, and Uğurcan (2016) aims to predict unsuccessful, successful, and at-risk firms by applying the Altman Model in measuring financial failure in firms registered in Borsa Istanbul. Within the scope of the research, financial failure forecasts were made between 2011 and 2015. In addition, the study tried to determine the level of impact of the analysed enterprises from possible financial crisis environments they may face in the future.

In Kulalı's (2016) study, the Altman Z-Score model is applied to 19 companies that experienced financial failure and bankruptcy while trading in the BIST between 2000 and 2013. It is aimed to evaluate the indicators in the model and to calculate the Type I error rate, which shows the ratio of companies included in the non-bankruptcy group despite being bankrupt. As a result of the study, it is concluded that the Z-Score model predicts bankrupt enterprises 95% one year before bankruptcy and 90% two years before the bankruptcy.

In İskenderoğlu and Karakozak's (2013) study, the Altman model Z-Score value is a combined ratio method with various financial ratios of 158 manufacturing industry enterprises traded on BIST between 2007-2011, calculated quarterly. In line with the study's results, it was determined that the global financial crisis in 2008 did not significantly affect the averages of ratios such as liquidity, cash, and current ratios, which show the ability of enterprises to fulfil their short-term liabilities.

Büyükarıkan and Büyükarıkan (2014) aimed to analyse the IT sector companies traded in Borsa Istanbul with Altman Z-Score and Springate financial failure models. The data used in the study were obtained from the consolidated financial statements of six firms operating in the IT sector for six accounting periods between 2008 and 2013. As a result of the study, based on the data obtained from the Altman Z-Score and S-Score models, it was found that the results of both models in determining financial failure are similar.

Rahayu, Suwendra, and Yulianthini (2016) aimed to determine and analyse the financial distress prediction of telecommunication enterprises traded on the Indonesia Stock Exchange for 2012-2014 with the Altman Z-Score, Springate S-Score and Zmijewski J-Score method. As a result of the study, two firms were found to be financially unsuccessful when the Altman Z-Score model was applied. Furthermore, when the Springate S-Score model was applied, four firms were found to be financially unsuccessful. Finally, when the Zmijewski J-Score model was applied, it was determined that the two firms were financially unsuccessful.

In the research conducted by Anjum (2012), the financial failure studies were analysed, and different models were compared. Among these comparisons, it was stated that models using multiple

discriminant analysis obtained the most effective results. It was concluded that the results of the Altman Z-score model could be applied for up to three years in predicting financial failure.

Şahin and Özkan (2022) analysed the financial success of 8 major automotive industry firms traded on the BIST during COVID-19, using data from 2017-2021. Within the scope of the analysis, z-score, s-score, t-score and j-score are used as financial failure models, and their results are compared. According to the study results, Altman Z-Score and Springate S-Score models report similar results. While automotive firms are expected to be negatively affected financially due to the unfavourable conditions created by COVID-19, the findings of the study do not support this expectation

The study by Pakdaman (2018) compares the results of Altman, Springate, Zmijevski and Grover models by predicting the financial failure of companies traded in the Tehran Stock Exchange. In this context, 35 companies from the textile and ceramics sector were selected, and their financial data covering the years 2011-2016 were analysed. As a result of the study, the Grover model predicts the highest number of firms experiencing financial stress, followed by the Altman and Springate models. The Zmijevski model, on the other hand, shows fewer firms in financial failure.

In the study by Poyraz and Uçma (2006), the financial failure levels of tourism, textile, agricultural products, food, and vehicles during the 1994 and 2001 crises are analysed with the help of the Altman Z (score) model. However, the z-score values, which measure the level of financial failure, are interpreted according to the sectors. As a result of this interpretation, it is impossible to predict the financial failure of the tourism, textile, agricultural products-food, and vehicles sectors, which constitute Turkey's main exporting sectors with the Altman z-score model.

Karadeniz and Öcek (2019) aimed to determine whether there is a statistically significant difference between the firms that carry the risk of financial failure and those that do not by examining the financial ratios of tourism enterprises whose shares are traded in Borsa Istanbul. For this purpose, 11 tourism companies were included in the analysis, and their financial data for the last six years were analysed and interpreted with the help of a z-score. As a result of this calculation, 66 observations were made on 11 companies selected from the tourism sector within the 6-year analysis period. In total, 29 of these observations did not show the risk of financial failure, 29 identified the risk of financial failure, and eight observations were found to be in the grey zone. After separating the enterprises included in the analysis according to their financial failure risks, 13 important financial ratios measuring liquidity, financial structure, activity, profitability and market performance were calculated and analysed to determine whether there is a statistically significant difference in these ratios.

Research methodology

Purpose of the study and sample selection

This study aims to predict financial failure by analysing the historical financial data of 45 manufacturing sector companies traded in BIST 100. Previous studies in Turkey have either used a single financial failure model or limited the number of enterprises and the number of years analysed. In order to avoid these limitations in our study, we selected three widely used financial failure models in the literature, and 45 of the 46 enterprises in the manufacturing sector in Borsa Istanbul were included in the study. The reason for not including the remaining enterprise in the study is the lack of financial data for the period to be analysed. The reason for choosing the manufacturing sector is that the models used for financial failure forecasting give the most accurate results in the manufacturing sector.

A literature review reveals that financial failure models have been studied over 1-2 years. Therefore, it is impossible to interpret whether there is an ongoing financial failure situation. Accordingly, this study analyses ten years and tries to measure how much financial stress shows continuity through financial failure prediction models. The study uses the financial statements of 45 manufacturing sector enterprises traded in Borsa Istanbul (BIST 100) for 2011-2020 as a data set. The financial statements and financial data of the enterprises analysed within the scope of the analysis were obtained from the Public Disclosure Platform (KAP) website. In addition, market capitalization data of these enterprises is obtained from IS Investment website.

Table 1: BIST 100 Manufacturing Sector Enterprises Included in the Study (2011-2020)

Company Name	Bist Code	Company Name	Bist Code
Anadolu Efes Biracılık ve Malt Sanayii A.Ş.	Aefes	Karsan Otomotiv Sanayii ve Ticaret A.Ş.	Karsn
Aksa Akrilik Kimya Sanayii A.Ş.	Aksa	Kartonsan Karton Sanayi ve Ticaret A.Ş.	Kartn
Alkim Alkali Kimya A.Ş.	Alkim	Kent Gida Maddeleri Sanayii ve Ticaret A.Ş.	Kent
Arçelik A.Ş.	Arclk	Kerevitaş Gida Sanayi ve Ticaret A.Ş.	Kervt
Bagfaş Bandirma Gübre Fabrikalari A.Ş.	Bagfs	Konya Çimento Sanayii A.Ş.	Konya
Brisa Bridgestone Sabanci Lastik Sanayi ve Ticaret A.Ş.	Brisa	Kordsa Teknik Tekstil A.Ş.	Kords
Birlik Mensucat Ticaret Ve Sanayi İşletmesi A.Ş.	Brmen	Kardemir Karabük Demir Çelik Sanayi ve Ticaret A.Ş.	Krdmd
Borusan Mannesmann Boru Sanayi ve Ticaret A.Ş.	Brsan	Nuh Çimento Sanayi A.Ş.	Nuhcm
Bursa Çimento Fabrikasi A.Ş.	Bucim	Otokar Otomotiv ve Savunma Sanayi A.Ş.	Otkar
Coca-Cola İçecek A.Ş.	Ccola	Oyak Çimento Fabrikalari A.Ş.	Oyakc
Çemaş Döküm Sanayi A.Ş.	Cemas	Parsan Makina Parçalari Sanayii A.Ş.	Parsn
Çemtaş Çelik Makina Sanayi ve Ticaret A.Ş.	Cemts	Petkim Petrokimya Holding A.Ş.	Petkm
Çimsa Çimento Sanayi ve Ticaret A.Ş.	Cimsa	Sasa Polyester Sanayi A.Ş.	Sasa
Deva Holding A.Ş.	Deva	Tat Gida Sanayi A.Ş.	Tatgd
Ege Endüstri ve Ticaret A.Ş.	Egeen	Türk Tuborg Bira ve Malt Sanayii A.Ş.	Tborg
Ege Gübre Sanayii A.Ş.	Eggub	Tofaş Türk Otomobil Fabrikasi A.Ş.	Toaso
Ereğli Demir ve Çelik Fabrikalari T.A.Ş.	Eregl	Tukaş Gida Sanayi ve Ticaret A.Ş.	Tukas
Ford Otomotiv Sanayi A.Ş.	Froto	Tüpraş-Türkiye Petrol Rafinerileri A.Ş.	Tuprs
Goodyear Lastikleri T.A.Ş.	Goody	Türk Traktör ve Ziraat Makineleri A.Ş	Ttrak
Gübre Fabrikalari T.A.Ş.	Gubrf	Ülker Bisküvi Sanayi A.Ş.	Ulker
Hektaş Ticaret T.A.Ş.	Hekts	Vestel Elektronik Sanayi ve Ticaret A.Ş.	Vestl
Jantsa Jant Sanayi ve Ticaret A.Ş.	Jants	Yataş Yatak Ve Yorgan Sanayi ve Ticaret A.Ş.	Yatas

Source: www.borsaistanbul.com

Variables

The study variables are Altman Z-Score, Springate S-Score, and Zmijevski J-Score. In addition, the financial data of 45 manufacturing sector enterprises traded in the BIST 100 were used to determine these values. These variables and the models to be used in the analysis are given in Table 3.

Table 2: Variables Used in the Study

Variables	Model
Altman Z-Score	X_1: Net Working Capital / Total Assets X_2: Retained Earnings / Total Assets X_3: Earnings Before Interest and Taxes / Total Assets X_4: Total Market Value of Equity Shares / Book Value of Total Debt X_5: Sales / Total Assets $\mathbf{Z=0.012X_1 + 0.014X_2 + 0.033X_3 + 0.006X_4 + 0.999X_5}$
Springate S-Score	X_1 = Working Capital / Total Assets X_2 = Earnings before Interest and Taxes/Total Assets X_3 = Earnings before interest and taxes / Short-term liabilities X_4 = Sales / Total Assets $\mathbf{S = 1.03X_1 + 3.07X_2 + 0.66X_3 + 0.4X_4}$
Zmijevski J-Score	X_1 = Net Profit / Total Assets X_2 = Total Debt / Total Assets X_3 = Current Assets / Short-Term Liabilities $\mathbf{J=-4.3-4.5X_1+5.7X_2+0.004X_3}$

The survival indicators (Z-value) of the Altman Z-Score model used to determine the risk of financial failure are interpreted as follows.

Values less than 1.81; Bankruptcy (financial failure); Danger area, the probability of financial failure is high.

Values between 1.81 - 2.99; Healthy area, Grey area, financial failure is difficult to predict.

Values greater than 2.99; Stable area (Financially successful) Financial failure is unlikely.

In the Springate S-Score model, another model used to determine the risk of financial failure, the survival indicators (S-value) are interpreted as follows.

S-Score > 0.862; The business is safe (successful).

S-Score < 0.862; The business is unsafe (unsuccessful).

The last model used to determine the risk of financial failure is the Zmijevski (J) Model. This model's survival indicators (J value) are interpreted as follows.

J-Score > 0.5; Business is safe (successful)

J- Score < 0.5; The business is insecure (failed)

Data Analysis

The firms to be evaluated according to the early warning models were selected from the manufacturing sector traded on Borsa Istanbul in Türkiye. A 10-year review was conducted based on the period between 2011-2020. As a result of this analysis, Altman Z-Score, Springate S-Score, and Zmijevski J-Score models were applied to the data of the companies in question, and the results were classified within their ranges. Table 4 shows the 10-year Z-scores, S-scores, and J-scores of 45 manufacturing enterprises operating in the BIST 100. The values are separated and coloured according to their classification degrees as successful, unsuccessful, and Altman Z-Score specific grey area.

Table 3: Calculated Scores of Companies for 2020

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	1.218	0.583	-1.4426	KARSN	1.847	1.304	-0.1054
AKSA	2.229	1.323	-1.1029	KARTN	15.404	2.739	-4.0004
ALKIM	7.888	3.005	-3.7368	KENT	56.969	1.033	-2.7068
ARCLK	1.893	1.01	-0.537	KERVT	2.419	1.247	-1.3857
BAGFS	1.171	0.297	0.3618	KONYA	12.427	0.635	-2.9211
BRISA	1.724	0.89	-0.3026	KORDS	1.337	0.541	-1.102
BRMEN	-11.137	-2.78	21.951	KRDMD	1.233	0.518	-0.6405
BRSAN	0.835	0.279	-1.0711	NUHCM	4.208	1.462	-3.614
BUCİM	4.2	1.594	-2.9776	OTKAR	2.236	1.166	-0.5069
CCOLA	2.174	1.151	-1.4196	OYAKC	3.456	0.848	-2.2313
CEMAS	3.796	0.669	-3.3805	PARSN	0.875	0.2	-1.3169
CEMTS	8.782	2.39	-4.1016	PETKM	1.877	0.94	-0.921
CIMSA	1.081	0.374	-0.7629	SASA	1.512	0.471	-0.2299
CMENT	2.865	0.047	-2.1133	TATGD	3.226	1.326	-2.1306
DEVA	3.436	1.82	-2.4873	TBORG	3.698	1.357	-2.2398
EGEEN	6.574	1.612	-3.4545	TOASO	2.393	1.039	-0.2729
EGGUB	3.285	1.162	-1.9122	TTRAK	3.507	1.842	-1.0773
EREGL	2.539	1.245	-2.7776	TUKAS	3.906	1.216	-1.5086
FROTO	4.135	1.889	-0.9678	TUPRS	1.466	0.407	0.539
GOODY	3.957	1.647	-2.0065	ULKER	2.21	1.49	-0.7017
GUBRF	3.06	0.782	-0.7324	VESTL	1.1	0.487	-0.4255
HEKTS	2.491	0.847	-0.9201	YATAS	3.079	1.558	-1.2108
JANTS	7.229	2.306	-3.5247	Ort.	4.351	1.066	-1.114

The calculated score values of the companies analysed within the scope of the study for 2020 are given in Table 3 above. ALKIM, BUCIM, DEVA, EGEEN, EGGUB, FROTO, GOODY, JANTS, KARTN, KENT, NUHCM, TATGD, TBORG, TTRAK, TUKAS and YATAS were found to be successful in all three models. On the other hand, BAGFS, BRMEN and TUPRS were identified as unsuccessful in 2020 in all three models.

Table 4: Calculated Scores of Companies for 2019

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	1.21	0.576	-1.6452	**KARSN**	1.005	0.674	-0.0856
AKSA	1.842	0.897	-0.9458	**KARTN**	9.113	2.256	-3.8428
ALKIM	6.378	2.907	-3.8872	**KENT**	7.402	0.965	-1.7032
ARCLK	1.951	0.973	-0.2679	**KERVT**	2.376	1.396	-0.7517
BAGFS	1.088	0.487	-0.3277	**KONYA**	8.856	0.605	-3.0751
BRISA	1.229	0.575	0.3722	**KORDS**	1.536	0.772	-1.0074
BRMEN	-1.218	-0.696	0.2963	**KRDMD**	1.153	0.425	-1.0487
BRSAN	1.048	0.452	-0.9761	**NUHCM**	2.576	1.01	-2.6392
BUCİM	3.515	1.082	-2.8476	**OTKAR**	2.829	1.538	-0.4733
CCOLA	1.952	1.008	-1.4424	**OYAKC**	6.003	1.153	-3.4368
CEMAS	0.588	0.121	-0.4185	**PARSN**	0.83	0.136	-0.9484
CEMTS	7.359	2.057	-3.6012	**PETKM**	2.121	1.031	-0.6401
CIMSA	1.124	0.317	-0.8279	**SASA**	0.783	0.053	-1.0988
CMENT	2.264	-0.188	-2.3507	**TATGD**	3.195	1.527	-1.8897
DEVA	2.43	1.575	-1.9055	**TBORG**	3.327	1.579	-2.2576
EGEEN	6.361	2.44	-3.8684	**TOASO**	2.986	1.235	-1.0015
EGGUB	2.013	0.792	-1.1993	**TTRAK**	2.775	1.296	-0.1955
EREGL	2.406	1.153	-2.6338	**TUKAS**	2.9	1.344	-1.1246
FROTO	4.261	1.689	-0.7112	**TUPRS**	2.345	0.818	0.0482
GOODY	4.302	2.522	-2.5228	**ULKER**	1.753	0.787	-1.0659
GUBRF	1.388	0.478	0.4738	**VESTL**	0.949	0.345	0.2437
HEKTS	2.856	1.794	-1.3897	**YATAS**	2.923	1.386	-1.3407
JANTS	4.632	1.947	-3.2179	**Ort.**	2.905	1.051	-1.448

The calculated scores of the companies analysed within the scope of the study for 2019 are given in Table 4 above. ALKIM, BUCIM, CEMTS, EGEEN, FROTO, GOODY, JANTS, KARTN, KENT, OYAKC, TATGD and TBORG companies were found to be successful in all three models, while BRISA, BRMEN, GUBRF and VESTL companies were found to be in financial distress in all three models. When the financial failure predictions of the companies in 2019 are generally examined, the number of companies in the grey area according to the z-score model is higher. The number of companies found to be successful according to the s-score and j-score models is higher.

Table 5: Calculated Scores of Companies for 2018

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	1.311	0.521	-1.6823	**KARSN**	0.848	0.571	0.6868
AKSA	2.011	0.994	-0.7631	**KARTN**	9.51	3.028	-4.2501
ALKIM	5.8	2.785	-3.4541	**KENT**	8.941	1.043	-2.0843
ARCLK	2.047	1.047	-0.3251	**KERVT**	2.16	1.15	0.078
BAGFS	0.577	-0.464	0.1979	**KONYA**	9.242	1.221	-3.3872
BRISA	1.487	0.904	0.2101	**KORDS**	1.855	0.966	-1.5815
BRMEN	-0.657	-0.445	-0.0678	**KRDMD**	1.964	1.493	-1.8196
BRSAN	1.261	0.661	-1.0578	**NUHCM**	2.539	1.048	-2.2323
BUCİM	4.587	2.508	-3.3432	**OTKAR**	2.266	1.194	0.1976
CCOLA	2.046	1.025	-1.2594	**OYAKC**	3.747	1.165	-2.8595
CEMAS	2.032	0.381	-0.2542	**PARSN**	1.346	0.458	-0.5488
CEMTS	6.948	3.712	-4.2099	**PETKM**	2.229	1.125	-0.7012
CIMSA	1.377	0.472	-1.1486	**SASA**	2.403	0.996	-1.5804
CMENT	2.067	0.039	-2.5601	**TATGD**	3.466	1.377	-2.0001
DEVA	2.075	1.306	-1.4519	**TBORG**	3.997	1.454	-2.7784
EGEEN	5.743	2.653	-4.5803	**TOASO**	2.844	1.057	-0.6389
EGGUB	2.589	0.952	-1.8805	**TTRAK**	3.008	1.563	-0.0706
EREGL	3.493	1.847	-3.0797	**TUKAS**	1.284	0.764	-0.4265
FROTO	4.705	1.765	-0.8167	**TUPRS**	3.62	1.691	-0.3808
GOODY	3.203	1.485	-1.2942	**ULKER**	1.972	1.165	-0.7227
GUBRF	1.672	0.762	-0.1411	**VESTL**	0.859	0.257	0.2835
HEKTS	2.958	1.606	-1.2973	**YATAS**	3.4	1.508	-1.4793
JANTS	4.292	2.004	-2.85	**Ort.**	3.424	1.120	-1.608

The calculated scores of the companies analysed within the scope of the study for 2018 are given in Table 5 above. ALKIM, BUCIM, CEMTS, EGEEN, EREGL, FROTO, GOODY, JANTS, KARTN, KENT, KONYA, OYAKC, TATGD, TBORG, TTRAK, TUPRS and YATAS were found to be successful in all three models. In contrast, the failure prediction of BAGFS, KARSN and VESTL was unsuccessful in all three models.

Table 6: Calculated Scores of Companies for 2017

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	1.424	0.563	-1.5978	**KARSN**	0.968	0.878	0.3353
AKSA	2.249	1.08	-1.2851	**KARTN**	10.409	1.954	-3.6835
ALKIM	6.068	2.02	-3.4167	**KENT**	14.837	1.244	-2.5548
ARCLK	2.525	1.062	-0.6495	**KERVT**	1.048	0.477	0.0972
BAGFS	1.355	0.404	-0.7011	**KONYA**	11.506	1.484	-3.4681
BRISA	1.523	0.75	0.1997	**KORDS**	2.287	0.938	-2.0846
BRMEN	-0.633	-0.233	-0.8903	**KRDMD**	1.04	0.555	-0.7381
BRSAN	1.37	0.672	-1.3245	**NUHCM**	2.814	0.837	-2.5813
BUCİM	3.407	1.487	-2.5348	**OTKAR**	2.652	1.126	0.434
CCOLA	1.884	0.716	-0.9394	**OYAKC**	6.162	1.621	-3.8248
CEMAS	1.484	0.175	0.1035	**PARSN**	1.105	0.318	-1.3085
CEMTS	4.812	1.606	-3.1037	**PETKM**	3.282	1.741	-2.1587
CIMSA	1.674	0.604	-1.3853	**SASA**	2.588	1.26	-1.6362
CMENT	2.784	0.402	-2.8996	**TATGD**	4.19	1.378	-2.4422
DEVA	2.005	1.005	-1.6172	**TBORG**	4.938	1.612	-2.9166
EGEEN	8.94	3.352	-4.2874	**TOASO**	2.634	0.907	-0.4428
EGGUB	3.513	1.292	-2.7094	**TTRAK**	3.829	1.738	-0.5947
EREGL	3.376	1.701	-2.9503	**TUKAS**	1.799	0.716	-0.8006
FROTO	4.008	1.533	-0.8669	**TUPRS**	2.688	1.21	-0.5683
GOODY	3.964	1.595	-1.8282	**ULKER**	2.024	0.993	-0.5566
GUBRF	1.483	0.42	-0.4653	**VESTL**	0.993	0.382	0.4794
HEKTS	3.187	1.527	-1.748	**YATAS**	3.445	1.588	-1.6074
JANTS	4.439	1.693	-2.8465	**Ort.**	3.346	1.013	-1.616

The calculated scores of the companies analysed within the scope of the study for 2017 are given in Table 6 above. ALKIM, BUCIM, CEMTS, EGEEN, EREGL, FROTO, GOODY, HEKTS, JANTS, KARTN, KENT, KONYA, OYAKC, PETKM, TATGD, TBORG, TTRAK and YATAS are predicted as financially successful in all three models. In contrast, BRİSA, CEMAS, KERVT and VESTL are predicted to be in financial stress in all three models.

Table 7: Calculated Scores of Companies for 2016

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	1.509	0.64	-1.7935	**KARSN**	0.28	0.031	0.5016
AKSA	2.316	1.072	-1.4699	**KARTN**	8.361	0.809	-3.1531
ALKIM	4.371	1.718	-3.1026	**KENT**	12.903	0.577	-1.8007
ARCLK	2.491	1.069	-0.9035	**KERVT**	0.016	-0.408	2.4572
BAGFS	1.462	0.239	-0.8064	**KONYA**	13.549	1.343	-3.5928
BRISA	1.54	0.675	0.1731	**KORDS**	2.093	0.927	-2.0945
BRMEN	-0.465	-0.259	-0.7642	**KRDMD**	0.755	0.295	-0.7162
BRSAN	1.094	0.485	-1.2704	**NUHCM**	4.369	1.594	-3.4099
BUCİM	3.884	1.689	-2.9351	**OTKAR**	2.488	0.973	0.5024
CCOLA	2.297	0.901	-1.2282	**OYAKC**	8.385	1.757	-3.9676
CEMAS	1.301	0.296	-1.3463	**PARSN**	1.097	0.133	-1.4948
CEMTS	3.565	1.35	-3.0164	**PETKM**	2.439	1.056	-1.8529
CIMSA	2.1	0.642	-2.0593	**SASA**	3.036	1.901	-2.0105
CMENT	2.722	0.434	-3.007	**TATGD**	4.613	1.698	-2.6905
DEVA	2.162	1.174	-1.6664	**TBORG**	4.002	1.537	-2.6706
EGEEN	9.44	3.333	-4.1033	**TOASO**	2.382	0.829	-0.3503
EGGUB	2.824	1.024	-2.1364	**TTRAK**	4.264	2.047	-0.9751
EREGL	2.383	1.096	-2.5579	**TUKAS**	2.023	1.015	-1.4159
FROTO	3.832	1.366	-0.9614	**TUPRS**	2.084	0.835	-0.3065
GOODY	4.644	1.545	-1.9981	**ULKER**	2.244	0.701	-0.6563
GUBRF	1.494	0.341	-0.4976	**VESTL**	1.33	0.625	0.2804
HEKTS	4.043	2.052	-2.5521	**YATAS**	2.409	1.238	-0.5262
JANTS	4.438	1.178	-2.7685	**Ort.**	3.346	1.013	-1.616

The calculated scores of the companies analysed within the scope of the study for 2016 are given in Table 7 above. ALKIM, BUCIM, EGEEN, FROTO, GOODY, HEKTS, JANTS, KONYA, NUHCM, OYAKC, SASA, TATGD, TBORG and TTRAK companies are found to be financially successful in all three models. In contrast, BRISA, KARSN, KERVT and VESTL companies are predicted to fail in all three models. However, considering the averages of the models, it is seen that the average is determined as successful in all three models.

Table 8: Calculated Scores of Companies for 2015

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	1.807	0.656	-1.7355	**KARSN**	0.765	0.385	0.7839
AKSA	2.995	1.299	-2.5901	**KARTN**	6.676	0.476	-3.2743
ALKIM	5.148	1.514	-3.2875	**KENT**	17.46	0.919	-2.7975
ARCLK	2.56	1.173	-0.76	**KERVT**	0.343	-0.112	1.7972
BAGFS	1.265	0.341	-1.995	**KONYA**	15.708	1.586	-3.6966
BRISA	2.604	1.124	-0.6884	**KORDS**	1.844	0.889	-1.9335
BRMEN	-0.35	-0.131	-1.2984	**KRDMD**	0.879	0.29	-1.1439
BRSAN	1.078	0.395	-0.8465	**NUHCM**	4.447	1.873	-3.3025
BUCİM	3.715	1.53	-2.7277	**OTKAR**	2.329	0.893	0.3582
CCOLA	2.73	0.922	-1.228	**OYAKC**	6.851	1.595	-3.8332
CEMAS	1.095	0.152	-1.7917	**PARSN**	1.174	0.307	-2.0579
CEMTS	4	1.198	-2.9852	**PETKM**	2.345	1.06	-1.9747
CIMSA	3.557	1.318	-2.8102	**SASA**	3.187	1.633	-2.1738
CMENT	2.899	0.56	-3.185	**TATGD**	4.379	1.557	-2.6094
DEVA	1.53	0.689	-1.376	**TBORG**	4.03	1.552	-2.5136
EGEEN	9.759	4.077	-4.228	**TOASO**	2.158	0.787	-0.4247
EGGUB	1.822	0.523	-1.0812	**TTRAK**	4.352	1.765	-0.9491
EREGL	2.893	1.217	-2.5848	**TUKAS**	2.099	0.936	-1.7196
FROTO	3.979	1.376	-1.0767	**TUPRS**	2.619	1.111	-0.884
GOODY	4.342	1.472	-2.2645	**ULKER**	3.392	1.469	-1.1301
GUBRF	2.006	0.789	-1.2001	**VESTL**	1.131	0.577	0.4531
HEKTS	3.795	1.794	-2.6273	**YATAS**	1.816	0.958	-0.4187
JANTS	4.65	1.23	-2.5326	**Ort.**	3.553	1.061	-1.785

The calculated scores of the companies analysed within the scope of the study for 2015 are given in Table 8 above. In 2015, AKSA, ALKIM, BUCIM, CEMTS, CIMSA, EGEEN, FROTO, GOODY, HEKTS, JANTS, KENT, KONYA, NUHCM, OYAKC, SASA, TATGD, TBORG, TTRAK and ULKER were determined as financially successful, while KARSN, KERVT and VESTL were determined as financially unsuccessful in all three models.

Table 9: Calculated Scores of Companies for 2014

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	2.182	0.679	-1.7652	**KARSN**	0.381	-0.087	0.6336
AKSA	2.808	1.103	-2.0909	**KARTN**	6.685	0.324	-3.2778
ALKIM	6.584	1.342	-3.3742	**KENT**	7.24	0.926	-2.3184
ARCLK	2.517	1.124	-0.7703	**KERVT**	0.322	0.205	1.8285
BAGFS	1.524	0.466	-0.8847	**KONYA**	13.99	2.048	-3.8828
BRISA	3.184	1.554	-1.1605	**KORDS**	1.687	0.741	-1.8644
BRMEN	-0.408	0.106	-1.0358	**KRDMD**	1.567	1.009	-1.492
BRSAN	1.098	0.387	-0.7223	**NUHCM**	4.115	1.53	-3.1511
BUCİM	4.666	1.957	-3.1276	**OTKAR**	2.256	0.859	0.0501
CCOLA	3.51	1.003	-1.4044	**OYAKC**	7.264	2.058	-4.0332
CEMAS	1.909	0.154	-2.8145	**PARSN**	2.081	0.623	-3.0247
CEMTS	5.045	1.467	-3.5479	**PETKM**	2.491	0.524	-1.8305
CIMSA	5.282	1.521	-3.533	**SASA**	2.647	1.504	-1.77
CMENT	2.389	0.794	-3.2567	**TATGD**	2.689	1.245	-2.5435
DEVA	1.233	0.651	-1.2087	**TBORG**	3.165	1.546	-2.43
EGEEN	11.734	4.292	-4.7496	**TOASO**	2.311	0.815	-0.7106
EGGUB	1.338	0.334	-1.0805	**TTRAK**	4.21	1.635	-1.2414
EREGL	3.063	1.413	-2.6457	**TUKAS**	-0.402	-0.339	0.4705
FROTO	3.334	1.007	-1.0999	**TUPRS**	2.424	0.745	-0.4813
GOODY	5.901	1.689	-2.725	**ULKER**	3.42	1.37	-0.9739
GUBRF	2.007	1.107	-1.0718	**VESTL**	1.28	0.604	0.3156
HEKTS	4.144	1.914	-3.0353	**YATAS**	1.594	0.958	-0.3487
JANTS	4.865	1.889	-3.2172	**Ort.**	3.407	1.084	-1.831

The calculated scores of the companies analysed within the scope of the study for 2014 are given in Table 9 above. In 2014, ALKIM, BRISA, BUCIM, CEMTS, CIMSA, EGEEN, EREGL, FROTO, GOODY, HEKTS, JANTS, KENT, KONYA, NUHCM, OYAKC, TBORG, TTRAK and ULKER were found financially successful while KARSN, KERVT, TUKAS and VESTL were found financially unsuccessful in all three models.

Table 10: Calculated Scores of Companies for 2013

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	1.792	0.506	-2.4925	**KARSN**	1.385	0.968	-0.4314
AKSA	2.761	1.044	-2.1896	**KARTN**	15.288	1.74	-4.0009
ALKIM	4.18	1.291	-2.7173	**KENT**	10.03	0.501	-1.997
ARCLK	2.552	1.2	-0.8283	**KERVT**	0.173	-0.01	2.2836
BAGFS	2.309	0.748	-1.0922	**KONYA**	14.787	1.362	-3.5372
BRISA	3.064	1.436	-1.2956	**KORDS**	1.732	0.721	-1.9652
BRMEN	-0.008	0.11	-1.2895	**KRDMD**	1.524	0.817	-1.4637
BRSAN	1.2	0.379	-0.6883	**NUHCM**	3.733	0.92	-2.5608
BUCİM	4.066	1.56	-2.599	**OTKAR**	2.369	0.995	-0.0021
CCOLA	3.26	0.918	-1.1884	**OYAKC**	7.013	2.1	-3.8342
CEMAS	2.393	0.405	-3.3421	**PARSN**	2.064	0.507	-3.1827
CEMTS	4.995	1.902	-3.5754	**PETKM**	2.774	0.772	-1.6108
CIMSA	4.692	1.283	-3.9376	**SASA**	1.917	0.973	-0.7815
CMENT	2.004	0.479	-2.8116	**TATGD**	2.772	1.303	-0.7698
DEVA	1.367	0.74	-1.4413	**TBORG**	2.927	1.521	-2.2822
EGEEN	5.187	1.917	-3.311	**TOASO**	2.65	0.911	-0.7022
EGGUB	1.808	0.342	-1.0625	**TTRAK**	5.611	2.379	-2.165
EREGL	2.511	1.295	-2.3341	**TUKAS**	0.184	0.361	1.2567
FROTO	3.897	1.297	-1.1689	**TUPRS**	2.485	0.755	-0.2028
GOODY	5.246	1.875	-2.8176	**ULKER**	2.815	0.862	-1.108
GUBRF	1.778	0.933	-0.7281	**VESTL**	1.202	0.535	0.1576
HEKTS	4.949	2.123	-3.4478	**YATAS**	1.466	0.863	-0.3497
JANTS	5.003	1.5	-2.2762	**Ort.**	3.509	1.048	-1.731

The calculated scores of the companies analysed within the scope of the study for 2013 are given in Table 10 above. In 2013, ALKIM, BRISA, BUCIM, CEMTS, CIMSA, EGEEN, FROTO, GOODY, HEKTS, JANTS, KARTN, KONYA, NUHCM, OYAKC and TTRAK were founded financially successful while KERVT, TUKAS and YATAS were found financially unsuccessful in all three models.

Table 11: Calculated Scores of Companies for 2012

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	2.915	0.81	-2.0848	**KARSN**	0.861	0.269	-0.163
AKSA	2.927	1.42	-2.5698	**KARTN**	16.908	2.092	-3.8593
ALKIM	3.101	1.095	-2.5914	**KENT**	13.323	0.898	-2.2509
ARCLK	2.372	1.047	-0.9512	**KERVT**	0.806	0.443	2.2529
BAGFS	5.464	1.289	-2.8422	**KONYA**	18.49	1.486	-3.7111
BRISA	2.941	0.933	-1.142	**KORDS**	2.126	0.935	-2.2324
BRMEN	-1.576	-0.343	-0.7108	**KRDMD**	1.743	1.102	-1.9352
BRSAN	1.667	0.519	-1.1079	**NUHCM**	3.254	0.59	-2.3512
BUCİM	3.885	0.992	-2.4742	**OTKAR**	2.135	0.926	-0.2085
CCOLA	3.634	1.39	-1.4682	**OYAKC**	6.243	1.222	-3.3051
CEMAS	1.264	0.197	-2.8573	**PARSN**	2.723	0.55	-3.1699
CEMTS	5.261	1.225	-3.6253	**PETKM**	2.908	0.759	-1.9603
CIMSA	2.547	0.806	-2.648	**SASA**	1.524	0.555	-0.3877
CMENT	2.129	0.316	-2.734	**TATGD**	2.401	1.064	-0.7679
DEVA	1.454	0.771	-1.7452	**TBORG**	0.705	0.896	-1.647
EGEEN	5.038	1.8	-2.7543	**TOASO**	2.386	1.013	-0.8138
EGGUB	2.199	0.37	-2.0055	**TTRAK**	4.873	2.271	-2.2805
EREGL	2.108	0.84	-1.8805	**TUKAS**	0.196	0.169	-0.3235
FROTO	4.286	1.709	-1.6425	**TUPRS**	3.672	1.448	-0.5671
GOODY	5.172	1.784	-2.5198	**ULKER**	2.097	0.974	-0.7087
GUBRF	2.512	1.441	-1.1567	**VESTL**	1.567	0.577	-0.0117
HEKTS	4.735	2.237	-3.6209	**YATAS**	1.282	0.654	-0.2261
JANTS	3.49	1.282	-2.3996	**Ort.**	3.594	0.996	-1.781

The calculated scores of the companies analysed within the scope of the study for 2012 are given in Table 11 above. In 2012, ALKIM, BUCIM, CEMTS, EGEEN, FROTO, GOODY, HEKTS, JANTS, KARTN, KENT, KONYA, OYAKC, TTRAK and TUPRS were found to be financially successful in all three models, while only KERVT was found to be unsuccessful in all three models.

Table 12: Calculated Scores of Companies for 2011

COMPANY	Z-SCORE	S-SCORE	J-SCORE	COMPANY	Z-SCORE	S-SCORE	J-SCORE
AEFES	2.247	0.946	-1.6285	KARSN	1.975	0.813	-0.178
AKSA	2.416	1.095	-1.7284	KARTN	15.925	2.63	-4.1054
ALKIM	2.949	1.226	-2.5671	KENT	11.885	0.507	-1.7799
ARCLK	2.198	0.984	-1.0424	KERVT	0.933	0.318	2.7018
BAGFS	5.212	1.962	-3.3188	KONYA	14.185	1.336	-3.5074
BRISA	2.973	1.13	-1.3751	KORDS	2.243	1.053	-2.2942
BRMEN	-0.536	0.111	-0.5882	KRDMD	1.976	1.336	-2.3657
BRSAN	1.574	0.579	-1.2817	NUHCM	4.371	0.929	-2.6906
BUCİM	5.063	1.773	-3.1789	OTKAR	2.147	0.789	-0.2697
CCOLA	3.292	1.289	-1.1698	OYAKC	10.798	2.699	-4.4246
CEMAS	1.358	0.386	-1.4864	PARSN	3.075	1.056	-3.672
CEMTS	4.551	1.857	-3.7168	PETKM	3.4	1.088	-2.3424
CIMSA	3.426	1.061	-2.9274	SASA	2.102	1.071	-1.3786
CMENT	2.625	0.74	-2.8312	TATGD	2.667	1.174	-0.7793
DEVA	1.501	0.603	-1.3862	TBORG	-0.644	0.259	-0.5429
EGEEN	3.324	1.859	-1.8736	TOASO	2.192	0.956	-0.505
EGGUB	2.029	0.523	-1.1409	TTRAK	4.65	2.252	-2.2591
EREGL	2.341	1.396	-1.942	TUKAS	-0.042	-0.207	0.9888
FROTO	4.574	2.046	-1.6496	TUPRS	4.012	1.738	-0.637
GOODY	4.049	1.582	-1.86	ULKER	1.543	0.672	-1.9914
GUBRF	1.901	1.152	-1.0602	VESTL	1.732	0.898	0.2225
HEKTS	2.884	1.331	-2.4745	YATAS	1.202	0.677	-0.2963
JANTS	1.483	0.977	-1.192	Ort.	3.461	1.126	-1.678

The calculated scores of the companies analysed within the scope of the study for 2011 are given in Table 12 above. In 2011, BUCIM, CEMTS, CIMSA, EGEEN, FROTO, GOODY, KARTN, KONYA, NUHCM, OYAKC, PARSN, PETKM, TTRAK and TUPRS were found to be financially successful in all three models, while KERVT and TUKAS were found to be unsuccessful in all three models.

Table 13: Percentage of Average Financial Success of Enterprises by Year

YEAR	Number of Enterprises	Z-Score			S-Score		J-Score	
		Successful	Grey Area	Failure	Successful	Failure	Successful	Failure
2020	45	%46.66	%26.66	%26.66	%64.44	%35.55	%93.34	%6.66
2019	45	%28.88	%37.77	%33.33	%57.77	%42.22	%88.89	%11.11
2018	45	%37.77	%37.77	%24.44	%71.11	%28.88	%86.67	%13.33
2017	45	%42.22	%26.66	%31.11	%66.66	%33.33	%86.67	%13.33
2016	45	%37.77	%35.55	%26.66	%55.55	%44.44	%88.89	%11.11
2015	45	%44.44	%31.11	%24.44	%64.44	%35.55	%91.12	%8.88
2014	45	%44.44	%28.88	%26.66	%57.77	%42.22	%88.89	%11.11
2013	45	%37.77	%33.33	%28.88	%59.99	%39.99	%93.34	%6.66
2012	45	%37.77	%35.55	%26.66	%62.22	%37.77	%97.78	%2.22
2011	45	%37.77	%37.77	%24.44	%68.88	%31.11	%93.34	%6.66

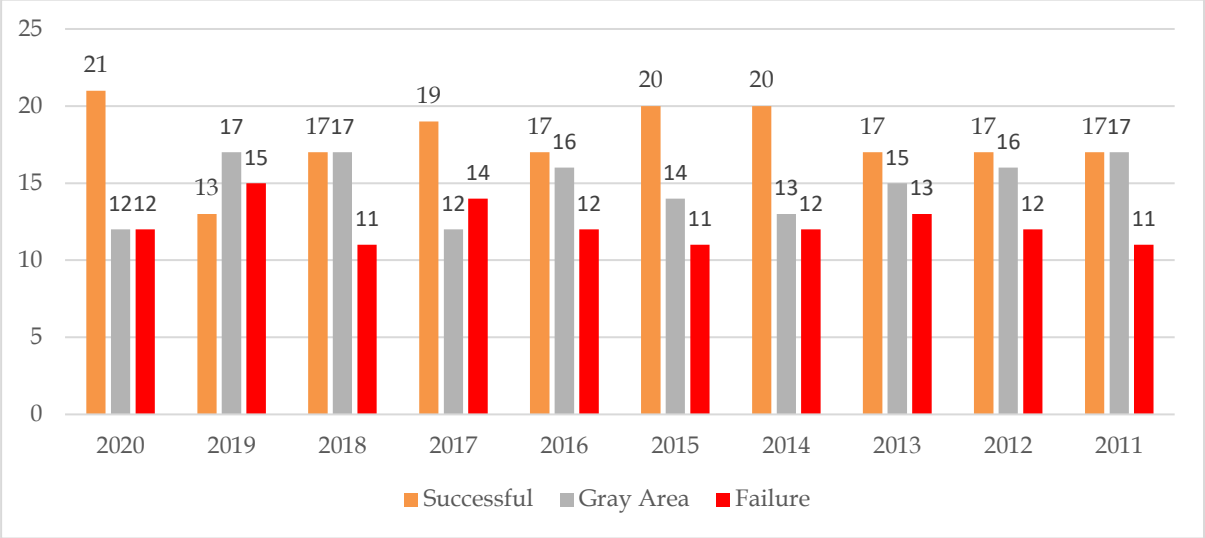
*Successful: Fixed Area (Secure)

*Grey Area: Healthy Zone. Bankruptcy is difficult to predict.

*Danger Area (Unsafe)

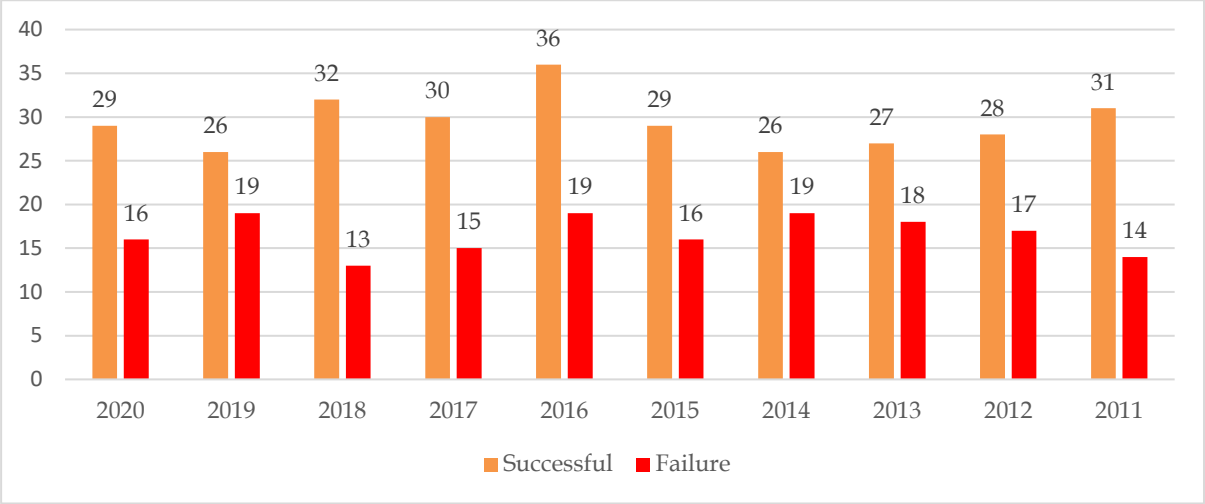
According to the table above, the Z-Score value of 46.66% of the enterprises included in the analysis is classified as successful in 2020. The number of enterprises whose financial success is classified in the grey area was highest in 2011, 2018, and 2019. The year in which 33.33% of the enterprises had a z-score indicating financial failure was 2019. The years in which S-Score values were ranked as financially successful were in 2018, with 71.11% of the enterprises, while 44.44% were classified as financially unsuccessful in 2016. Finally, according to the J-Score values examined, 13.33% of the enterprises were considered financially successful in 2018 and 2017, while 93.34% of the enterprises were found to be financially unsuccessful in 2011,2013 and 2020,

In general, while the financial success rates of the firms between 2014 and 2017 and thus their score values increased, in the following years, 2018 and 2019, an increase is observed in the proportion of firms classified in the grey area due to the uncertainty. According to the analysis, the year with the most negative model results in terms of financial failure is 2019. Furthermore, in all three models applied, the values indicating financial failure are at the highest level in percentage terms in 2019, which was obtained as a result of the year when the number of financially unsuccessful enterprises increased.



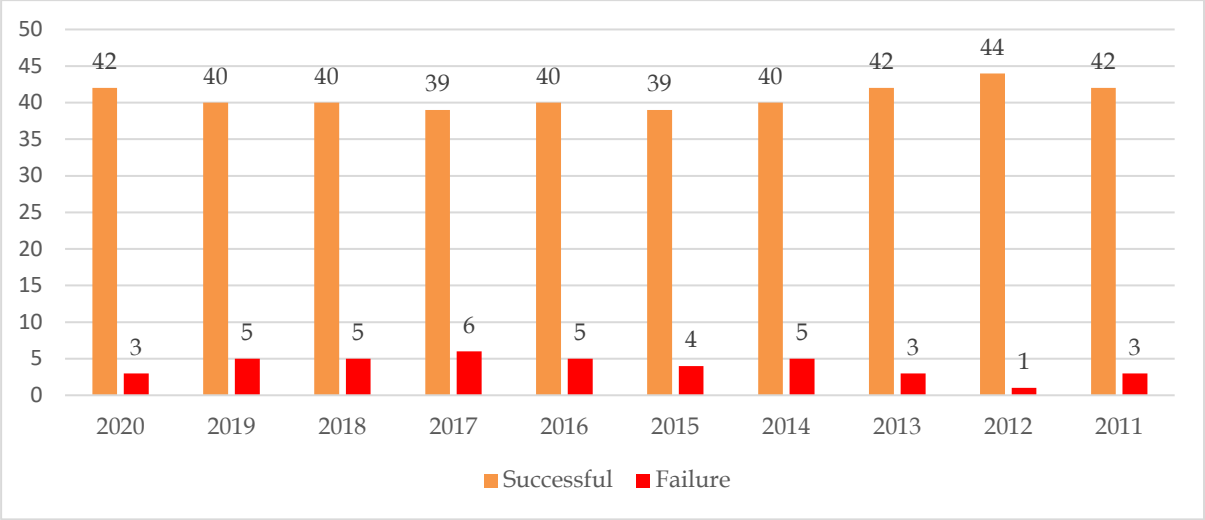
Graph 1: Changes in Altman Z-Score Values of Enterprises by Years

While the highest number of firms with a Z-Score value greater than 2.99, that is, the number of firms classified as successful, is between 2015 and 2014, the highest number of firms in the grey area with a Z-Score value of 1.81 - 2.99 is observed in 2019, 2018 and 2011. According to the Z-Score, which accepts values less than 1.81 as financially unsuccessful, the highest number of unsuccessful enterprises was observed in 2019. In 2015-2014, the financial success of the enterprises was almost the same. However, with the increase in the uncertainty represented by the grey area, changes were observed in the number of enterprises.



Graph 2: Changes in Springate S-Score Values of Enterprises by Years

The highest number of enterprises with an S-Score value greater than 0.862 financially successful was observed in 2016. On the other hand, the S-Score, which considers values less than 0.862 as unsuccessful, is seen as the years with the highest number of financial failures with the equal number of enterprises in 2019, 2016, and 2014.



Graph 3: Changes in Zmijevski J-Score Values of Enterprises by Years

According to J-Score, which considers values below 0 as successful, the highest number of successful enterprises was observed in 2012. On the other hand, J-Score considered values greater than 0 as financially unsuccessful, and 38 enterprises were classified as unsuccessful in 2017.

Conclusion

In this study, Altman Z-Score, Springate S-Score, and Zmijevski J-Score models, the most preferred early warning models developed for financial failure, are applied to the data of 45 manufacturing industry enterprises traded in Borsa Istanbul between 2011-2020. As a result of this application, the model results are compared and analysed in detail.

Since the model result values of all enterprises included in the scope of the analysis cannot be listed within the study's limits, the analysis results are presented collectively by years of financial success and failure in percentages.

According to the Altman Z-score model, all financial failure forecasts of BUCIM, EGEEN, FROTO, GOODY, JANTS, KARTN, KENT, KONYA and OYAKC for the period between 2011 and 2020 are in the safe zone. In other words, according to the z-Score model, there has been no financial failure in the last ten years of these nine companies. ARCLK, CMENT, OTKAR and TOASO were in the grey area where the risk of financial failure may be present, albeit low, in all years examined. BRMEN, BRISA and VESTL have been identified in the unsafe area with a risk of financial failure in all years analysed.

According to the Springate S-Score model, the financial failure forecasts of AKSA, ALKIM, ARCLK, BUCIM, CCOLA, CEMTS, EGEEN, EREGL, FROTO, GOODY, HEKTS, JANTS, TATGD and TTRAK for the period between 2011 and 2020 were found to be in the safe zone which indicates no financial failure risk for the ten years examined. On the other hand, BRMEN, BRSAN, CEMAS, CMENT and VESTL are estimated to have a high risk of financial failure in all ten years.

According to the Zmijevski J-Score model, AEFES, AKSA, ALKIM, ARCLK, BRSAN, BUCIM, CCOLA, CEMTS, CIMSA, CMENT, DEVA, EGEEN, EGGUB, EREGL, FROTO, GOODY, HEKTS, JANTS, KARTN, KENT, KONYA, KORDS, KRDMD, NUHCM, OYAKC, PARSN, PETKİM, SASA, TATGD, TBORG, TOASO, TTRAK, ULKER and YATAS companies' financial failure forecasts for the period 2011-2020 were all determined as successful. In this study on the manufacturing sector, it is observed that in 2020, all three models gave the same results for 19 companies, 16 of which were successful and three unsuccessful. Z-score and s-score obtained the same results for 28 companies. S-Score and J-score have the same prediction results for 32 companies. In 2019, the same results were obtained from all three models for 16 companies, 12 successful and four unsuccessful. Z-score and s-score obtained similar results for 27 companies. S-Score and J-score had similar prediction results for 31 companies. In 2018, all three models obtained the same results for 20 companies, 17 successful and three unsuccessful. Z-

score and s-score obtained similar results for 27 companies. Similar prediction results were found for S-Score and J-score for 32 companies. In 2017, all three models obtained similar results for 22 companies, 18 successful and four unsuccessful. Z-score and s-score obtained similar results for 32 companies. In S-Score and J-score, common prediction results were found in 32 companies. In 2016, all three models yielded the same results for 18 companies, 14 successful and four unsuccessful. Z-score and s-score obtained similar results in 27 companies. Similar prediction results were found for S-Score and J-score for 29 companies. In 2015, all three models yielded the same results for 22 companies, 19 successful and three unsuccessful, while Z-score and s-score yielded similar results for 30 companies. In S-Score and J-score, common prediction results were found in 28 companies. In 2014, all three models obtained the same results for 22 companies, 18 successful and four unsuccessful, while Z-score and s-score obtained similar results for 28 companies. In S-Score and J-score, common prediction results were found in 28 companies. In 2013, all three models yielded the same results for 18 companies, 15 successful and three unsuccessful, while Z-score and s-score yielded similar results for 27 companies. In S-Score and J-score, common prediction results were found in 29 companies. In 2012, the same results were obtained from all three models in 15 companies, 14 successful and one unsuccessful, while Z-score and s-score obtained similar results in 24 companies. In 2011, all three models obtained the same results for 16 companies, 14 successful and two unsuccessful, while Z-score and s-score obtained similar results for 23 companies. Similar prediction results for S-Score and J-score were found for 29 companies.

As a result of the analysis, the prediction results of the financial failure prediction models Springate s-score and Zmijevski J-score are found to be closer to each other. In contrast, Altman Z-score results differ from the other two models. According to the literature review, it is generally observed that narrower studies have been conducted in terms of the years studied. As a result of the findings of these studies, the results of the Altman and Springate models are closer to each other. The Zmijevski j-score model has not been compared sufficiently among the financial failure models. However, this study shows that the Springate model gives more similar results to the Zmijevski model. Therefore, the Altman Z-score model produces similar results to the Springate S-score model, as observed in previous studies, because no other model was included. Hence, our study provides a comparison between the three models.

In addition, in this study, the results obtained from the financial data of 45 manufacturing companies between 2011 and 2020 are used to predict financial failure. It can be interpreted that the financial situation of the companies in the manufacturing sector is generally healthy and away from the danger of bankruptcy according to all models except the Z-Score average of 2019.

While the phenomenon of financial success and failure is examined by accepting the internal factors of firms as the framework of analysis, the effects of sectoral dynamics and macroeconomic variables that constitute the economic environment of firms on model result values emerge as possible research areas. Furthermore, in line with the fact that economic activity is primarily realized through small and medium-sized enterprises in terms of their contribution to the level of employment and economic output, academic and practice-oriented research aiming to ensure the integration of financial success and failure measurement and prediction models with organizational cultures in SMEs within the framework of management practices and performance evaluation approaches are considered as possible areas of study.

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